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SYNTHESIS OF EMPTY FRUIT BUNCHES CARBON POLYMER COMPOSITES AS GAS DIFFUSION LAYER FOR ELECTRODE MATERIALS

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ABSTRACT

SYNTHESIS OF EMPTY FRUIT BUNCHES CARBON POLYMER COMPOSITES AS GAS DIFFUSION LAYER FOR ELECTRODE MATERIALS. Empty Fruit Bunches (EFB) of oil palm has been used, for example, for biofuels, automotive components, particle board, as a carbon source. Carbon material scan be widely used for many applications, for hydrogen storage, conductive or reinforcement plastics, catalyst supports, batteries and fuel cells. In this study, EFB carbon powder has been used as a raw material to make sheets of carbon-polymer composites. The composition of the composite sheet was varied, the electrical properties of the sheets were measured to determine the potential application as a Gas Diffusion Layer for Proton Exchange Membrane Fuel Cell (PEMFC) electrodes. Composites made with carbon composition weight % compared to the polymer are 65/35, 70/30, 75/25 and 80/20. The materials used is EFB carbon powder as a result of the pyrolysis temperature of 900 °C for 1 hour, then crushed and sieved to 200 mesh size, and the polymer was ethylene vinyl acetate. The raw materials are mixed in a solvent xylene, and printed using tape casting method, then dried at room temperature. The electrical properties were tested using a HIOKI 3522-50 LCR meter HiTESTER The measurement results show that the greater the ratio of carbon to polymer, the higher the electrical conductivity, the values are between 1.54 S/m -11.34 S/m. Morphology of the composite sheet was observed using Scanning Electron Microscope (SEM) to determine the distribution of carbon and polymer. According to the measurement of morphology and electrical conductivity, the composite is suitable for the gas diffusion layer of the PEMFC electrode.

Keywords : Composite, Empty fruit bunches, Gas diffusion layer, Electrical conductivity

ABSTRAK

PEMBUATAN KOMPOSIT KARBON TANDAN KOSONG KELAPA SAWIT POLIMER SEBAGAI BAHAN *GAS DIFFUSION LAYER* UNTUK MATERIAL ELEKTRODA. Tandan kosong kelapa sawit telah banyak dimanfaatkan, misalnya untuk *biofuel*, komponen otomotif, papan partikel, sebagai sumber karbon. Bahan karbon dapat digunakan secara luas untuk beberapa aplikasi, contohnya untuk penyimpan hidrogen, penguat plastik atau konduktif, *catalyst supports*, *batteries* dan *fuel cells*. Pada percobaan ini, serbuk karbon Tandan Kosong Kelapa Sawit (TKKS) telah digunakan sebagai bahan dasar membuat lembaran komposit karbon polimer. Komposisi bahan komposit divariasikan, sifat listrik lembaran diukur untuk mengetahui potensi aplikasinya sebagai *Gas Diffusion Layer* pada elektroda *Proton Exchange Membrane Fuel Cell* (*PEMFC*). Komposit dibuat dengan komposisi: % berat karbon dibanding polimer adalah 65/35, 70/30, 75/25 dan 80/20. Bahan yang digunakan adalah serbuk karbon sebagai hasil pirolisis TKKS pada suhu 900 °C selama 1 jam, lalu digerus dan diayak hingga berukuran 200 *mesh* dengan polimer *ethylene vinyl acetate*. Bahan baku dicampur dalam pelarut *xylene*, lalu dicetak menggunakan metode *tape casting*, selanjutnya dikeringkan pada suhu ruang. Sifat listrik diuji menggunakan alat *LCRmeter* HIOKI 3522-50 HITESTER. Hasil pengukuran menunjukkan bahwa makin besar perbandingan karbon terhadap polimer, makin tinggi konduktifitas listriknya, nilainya antara 1,54 S/m hingga 11,34 S/m. Morfologi lembaran komposit diamati menggunakan *Scanning Electron Microscope* (*SEM*) untuk mengetahui distribusi karbon dan polimernya. Sesuai hasil pengamatan morphologi dan pengukuran konduktivitas listriknya, komposit ini cocok sebagai *Gas Diffusion Layer* untuk *PEMFC*.

Kata kunci: Komposit, Tandan kosong kelapa, Lapisan difusi gas, Konduktivitas listrik

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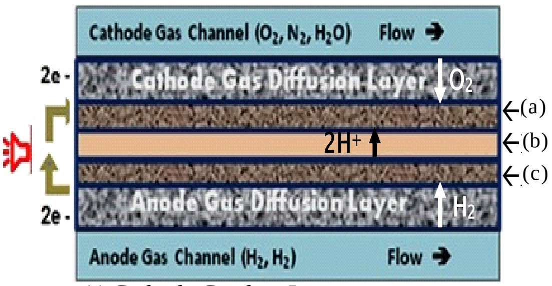
INTRODUCTION

The Proton Exchange Membrane Fuel Cell (PEMFC) is becoming center of attention as an alternative power source for automotive and stationary applications, since it is capable of producing high power densities under rapid change in load [1-3]. It is a new energy generating and renewable which is environmental friendly is alternative energy source that needs to be developed to overcome the energy crisis and reduce the impact of global warming. The fuel cell produces electrical energy from the electrochemical reaction between hydrogen gas and oxygen gas. A PEMFC consists of components of the electrolyte or the proton exchange membrane and GDE that composed of sheets of Gas Diffusion Layer (GDL) and Catalyst Layer (CL), see Figure 1.

GDL is part of the fuel cell electrode is one of the main components in PEMFCs. The GDL plays a key role on reactant gas diffusion and water management in PEMFCs, that have several functions: a) to diffusion of hydrogen (anode) and oxygen gas (cathode), b) as a catalytic support, and c) as a conductive medium of electrons movement [4]. GDL is a layer of material, which is usually a composite material, consisting of carbon dab polymeric materials. A single-layer GDL is typically carbon-based product, including woven carbon cloth [5], non-woven carbon paper [6], carbon felt, carbon nano tubes [7], and carbon foam. These carbon materials requires a production process that relatively complicated, thus affecting the selling price.

Research on the manufacture of carbon from oil palm empty fruit bunches have been done with a relatively simple process, and potentially replace charcoal products commercially, because carbon is porous and conductive properties, as specified by the electrode material for PEMFC [8]. Carbon-based GDL is widely used because (i) it is stable in acid environment, (ii) provides high gas permeability and good electronic conductivity, (iii) is elastic on compression, and (iv) controls porous structure of a dual-layer GDL [3, 9].

Carbon-fiber paper or cloth has been typically employed as a substrate for the GDL in PEM fuel cells. Conventionally, carbon fibers are graphitized at high



(a):Cathode Catalyst Layer
(b):Proton Exchange Membrane
(c):Anode Catalyst Layer

Figure 1. Component of Proton Exchange Membrane Fuel Cell

temperature (>2000 °C) to enhance electronic conductivity and mechanical strength, and impregnated with thermoset resin to manufacture carbon papers. Carbon cloths are produced by spinning and weaving of carbon yarns, followed by carbonization or graphitization [10, 11]. More details for carbon-fiber products and processing can be found in Reference [10]. Modification of carbon-fiber cloth by phenolic resin before carbonization [12] improved fuel cell polarization behavior without significant ohmic and mass transfer losses.

In this research, composites for GDL was made of carbon materials and polymers with different compositions to determine the effect of carbon content on its electrical properties. Carbon is made from palm oil waste, such EBFS through pyrolysis process, and has been observed morphology and electrical conductivity

EXPERIMENTAL METHOD

Carbon-polymer composite materials for applications as PEMFC Gas Diffusion Layer has been made of the carbon material, which is the result of the pyrolysis of oil palm empty fruit bunches at a temperature of 900 °C for 1 hour, carbon powder 200 mesh size. The polymer used is ethyl vinyl acetate and a plasticizer poly ethylene glycol 30%. Composites are made varying the composition of the carbon and polymer are 65%:35%, 70%:30%, 75%:25% and 80%:20%. Ingredients are mixed in xylene medium at a temperature of 55 °C for 1 hour followed at a temperature of 124 °C for 30 minutes, then printed using tape casting technique, and dried at room temperature. Electrical conductivity is determined using HIOKI 3522-50 LCR-meter HiTESTER, and morphology is observed by Scanning Electron Microscope (SEM) JEOL JSM-6390 Series.

RESULTS AND DISCUSSION

Composite morphology was observed using Scanning Electron Microscope (SEM) is shown in Figure 2 and Figure 3, which indicates that the carbon polymer composites is quite homogeneous, observed on the top surface, bottom surface and cross section of one side. Pores are scattered fairly evenly throughout the body of the composite, the surface pore over more of the bottom surface, it is likely due to the speed of the liquid polymer settles by gravity is greater than the speed of freezing liquid polymer.

The pores diameter between of 1μm to 30 μm, and thick composite approximately is 85 μm. Data mapping looks deployment carbon material (pink), polymer (green) and pores (black) is quite homogeneous. Materials with composition 90/10 was made as well, but after drying, the raw materials are not fused so that the composite sheet is not formed.

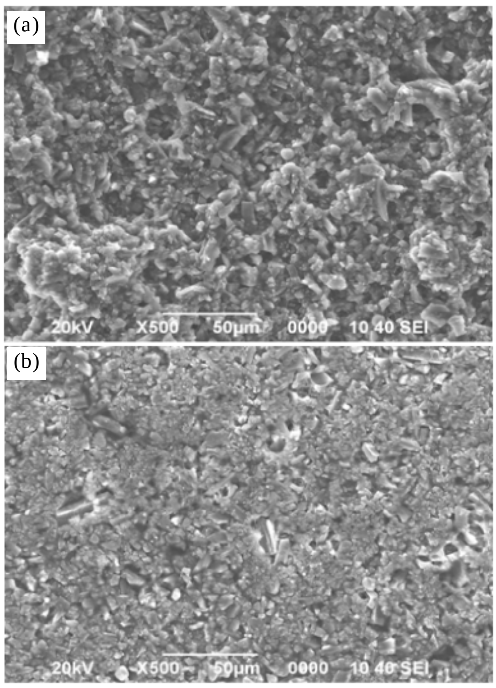


Figure 2. GDL sheet morphology with composition for carbon: polymer = 80:20, (a). The upper surface and (b). Bottom.

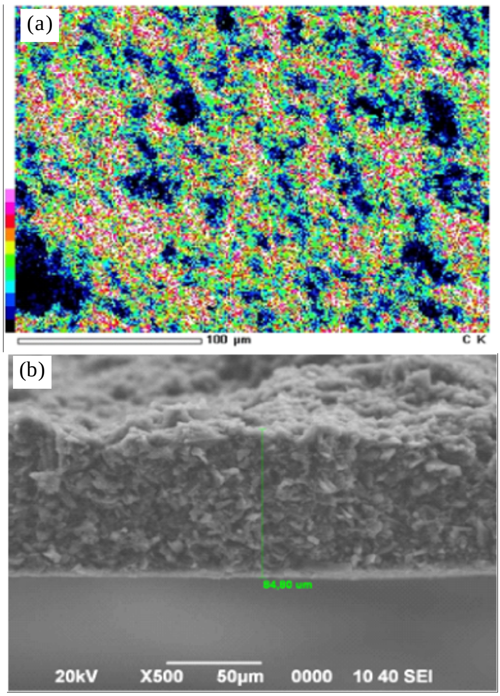


Figure 3. Mapping (a). The upper surface and (b). Cross section

Electrical conductivity of the composite has been measured at frequencies 1-100000 Hz, shown in Figure 4, which indicates that the carbon content affects the electrical conductivity of the composites. The more the carbon content, the higher electrical conductivity of composite, the average value was 11.34 S/m, 9.09 S/m, 5.71 S/m and 1.54 S/m, respectively for the composition of 65 % : 35 %, 70 %: 30 %, 75 % : 25 % and 80 % : 20 %.

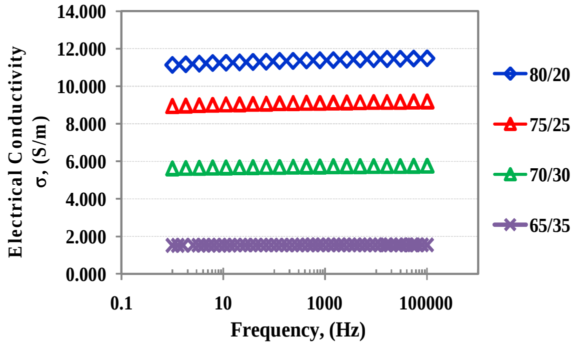


Figure 4. Electrical conductivity of composite material sin the varying compositions

However, the electrical properties of carbon materials still can be improved so that the quality of the composite have better electrical properties as the base material for roton Exchange Membrane Fuel Cell (PEMFC) electrodes

CONCLUSION

According to the measurement of morphology and electrical conductivity, the composite is suitable for the gas diffusion layer of the Proton Exchange Membrane Fuel Cell (PEMFC) electrode. However, the electrical properties of carbon could be enhanced in order to achieve the required properties as a base electrode PEMFC.

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